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ABSTRACT

The proposed changes and plans for a new science methods course in an elementary teacher education program at Utah State University are discussed in this paper. The course uses a hands-on individualized curriculum which emphasizes an interactive student and teacher problem solving and helping relationship. Information presented in this paper includes: (1) introduction (reviewing background information, planning methodology, and rationale); (2) curriculum framework (listing the major goals and objectives which form the basis of the course's content and activities); (3) component inputs, processes, and outputs (specifying each topic's components); (4) research justification by goal and topic (providing philosophical and/or research support for each component); (5) conformation to the National Science Teachers Association's recommended standards (explaining how the program relates to the proposed standards); (6) summary statement; and (7) a listing of 128 references. (ML)

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Foundations for An Elementary Science Methods Course

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INTRODUCTION

General Background Information: Contributions to General Philosophy

Researchers have long been dismayed by the apparent misconceptions about science held by students (Bady, 1979; Cooley & Klopfer, 1963: MacKay, 1971: Mead & Metraux, 1957; Rubba, Horner, & Smith, 1981) as well as about the misconceptions possessed by science teachers (Carey & Strauss, 1968, 1970; Miller, 1963; Schmidt, 1967). Consequently, with the anticipation that improved student conceptions would necessarily follow, much time and effort have been invested in programs designed to improve science teachers' conceptions of science. Such programs (e.g. Billeh & Hassan, 1975; Carey & Stauss, 1968, 1970; Welch & Walberg, 1968) assumed that a teacher's classroom behavior is influenced by his/her conceptions of the nature of science and that a significant positive relationship, therefore, exists between teachers' conceptions and changes in the conceptions of their students. However, recent research (Lederman, 1983) has failed to support this intuitive notion. In addition, curricula specifically designed to promote improved student conceptions of the nature of science have provided only limited success.

In an attempt to relate teaching behavior and classroom climate to students' conception of science, Lederman (1986) identified four variables as "generic" by virtue of their pervasive importance with respect to conceptions of science. They were:

(1) The teachers/classes of the "high" group were typically more pleasant and supportive.

(2) The telling of anecdotes, use of humor, and instructional digression by teachers was more evident in the "high" group.

(3) The "high" group had dynamic teachers.

(4) The "high" group classes employed a variety of instructional media.

Other variables identified in the study may be considered prerequisite variables since they facilitate learning when present. They include:

(1) Frequent questioning.

(2) Questions of a higher cognitive level.

(3) A problem solving approach.

(4) Sequential probing of student responses.

(5) Relating subject matter to students' lives.

Research supports the generalization that people learn more when they are interested, and that they are generally more interested if the environment is pleasant. In this regard, a number of broad, underlying principles have been identified that form a general framework for the science methods course. These principles are further discussed in the section that follows.

It is almost self-evident that what interests one person may not interest another (Cronbach and Snow, 1977). The case for a partially individualized approach to teaching may be based on the following assumptions:

(1) A stimulating environment with an enthusiastic teacher is prerequisite to learning.

(2) If given a choice, students will avoid unpleasant experiences and choose pleasant ones.

Piper (1977a) identified four science methods course characteristics considered important by preservice elementary teachers. They were: (1) competencies to be mastered in the course were publicly stated; (2) the instructors modeled the behaviors which preservice elementary teachers were expected to demonstrate; (3) campus activities were planned to assist preservice elementary teachers in having successful field experiences; and (4) instructors provided personalized feedback following field experiences.

Piper (1977b), in another study of science methods courses, also found that stated competencies and field experiences were one way to produce more positive student attitudes toward science.

Science is often not perceived by students as a most desirable course choice (Gallup 1978). The reputation science has for being difficult does not help the situation. Some of this problem can be attributed to the frustration and lack of interest generated by a disparity between the logical operations utilized in teaching many physical science courses and the fact that most students are not at the Piagetian level of formal operations (Herron 1975, 1978).

Griffiths (1976) in studying college chemistry and physics students, determined that only about 30% were at the formal operations level. This finding compares favorably with work done by McKinnon and Renner (1971) in which they determined that only 25% of college freshman in their sample were already at the formal stage. Another study by Lawson and Renner (1974) produced similar results. Elementary education majors may be functioning at an even lower percentage level (Lawson, et. al. 1975).

A success-oriented science program must accommodate student ability. Content and methods course students should have concrete experiences as dictated by the fact that most are not at the formal operations stage. However, success in science methods alone may not be sufficient to motivate students to teach science. Bandura (1977) has described a theory of "self-efficacy" which suggests that if a student attributes success to luck rather than ability and effort, success may not lead to greater interest and effort in the future. Students should experience the methods course in such a way that they can attribute their success to personal effort and ability. Katona (1940) identified the strategy of "learning by help." This process focused on principles that must be considered in solving

problems. Whimbey (1977) indicated that when the instructor "thinks aloud" to facilitate student understanding of strategies, errors in student thinking will become more evident. The above components contribute to a philosophy best exemplified in the "helping relationship" approach.

The essence of the "helping relationship" approach is that a learning experience should be a joint enterprise of students and teachers attempting to identify and practice ways of relating to each other as real persons in a creative setting (Rogers, 1961, 1963a, 1963b; Faw, 1949, 1957). The basic ingredient in the "helping relationship" approach is people.

Various strategies for problem solving may be utilized in the "helping relationship" situation. Affective considerations include:

(1) The student must desire a solution.

(2) The student must feel he/she has the ability to solve the problem.

(3) The student must desire to begin an attack on the problem.

Acting out, making a model, working backwards, and the Polya 4 - State Model (Polya, 1957) may be utilized to enhance problem solving. Working in small groups definitely facilitates problem solving (Suydam and Weaver, 1977). These components of research on problem solving can justifiably be applied to the science method course, with criterion for application: does the component help create an environment conducive to problem solving? Studies by Brownell (1942) Maier (1970), Simon (1976), and Wheatley (1977) have contributed to structuring problem solving situations in the methods course.

All courses have a stated curriculum framework consisting of goals and objectives. The logic of the framework may never be perceived by the student (Ausubel, 1963). Research suggests that students need to know what is expected of them (Baker, 1969; Duchastel & Merrill, 1973; Gleit &

Elington, 1978: Heron, 1971; Kibler et al., 1970). The more freedom students have in the learning process, the more important objectives are in facilitating learning. These factors suggest that there is merit in providing the student with objectives and an explanation of the process involved in achieving the objectives.

In summary, the teacher is an important factor in a people oriented course. The teacher should be an active agent in the learning process. The humanness of the teacher helps facilitate an atmosphere where learning becomes a joint process. Individualization and accomodation of abilities and needs of students must be a part of the process, and though students must be successful, the changes of the curriculum must produce a sense of accomplishment.

Planning Methodology

A Discrepancy Evaluation Model (DEM) was used in planning the overall design of the science methods course (Yavorsky, 1976). The program design constitutes a structured description of the program. Information is organized in such a way that it can be used as an operational map of the program. The design includes: what is going to happen (activities--process), what should result if the activities are carried out (objectives--outcomes), and what is needed to carry out the activities (resources--input).

In discrepancy evaluation, performance is compared to a standard. A program design serves as the formal representation of that standard and is to be stated in a form which makes standards readily subject to evaluation.

If organized properly, the program design should:

1. facilitate clarification of program goals;
2. facilitate the total planning process;

3. form a basis for analyzing costs in time and money;

4. facilitate assessment of the program plan before implementation;

5. provide an implementation guide;

6. provide a sense of the whole;

The program design for the course is organized around three information categories: inputs, processes, and outputs. The course may be thought of as a system utilizing inputs (teachers, students, desks, paper, etc.) in processes (classes, practica, testing, etc.) to produce certain outputs (knowledge, skills, attitudes, etc.). Inputs (I), processes (P), and outputs (O) can be conceptualized at different interacting levels. In order to note the different level interactions, functional dependencies between components are pictured and a numbered in a prescribed manner. This system is evidenced in the conceptual framework and I-P-Os that follow.

Total Program Framework - SODIA Pre-1985

The acronym SODIA represents the Utah State University Elementary teacher education program. The name is derived from the first letters of the descriptive words (self, others, discipline, implementation, and associate teaching), which represent the five levels of the program. No research justification is provided in this paper for the total program.

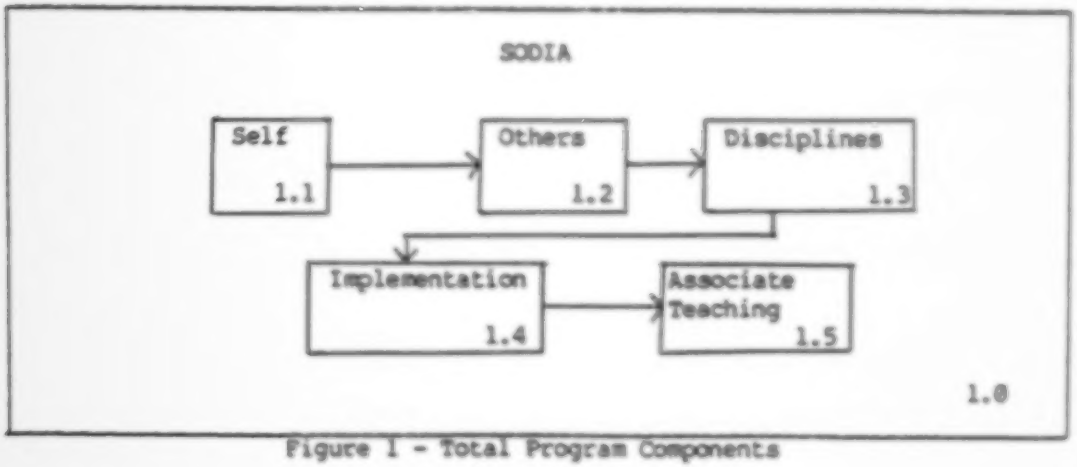


Figure 1 - Total Program Components

Level I, Self, is represented by the letters "S" in the acronym SODIA. At this introductory level, emphasis is on student understanding of the relationships between the individual and ability and desire to teach. Students in Level I receive a minimum of 10 hours of observation in elementary schools at various grade levels. Additional classwork and counseling provide a variety of other experiences to help students decide whether teaching is really the profession they are interested in pursuing.

INPUTS	PROCESS	OUTPUTS
Level I, Self I.1		
* 300 Students per year * 6 Faculty (FTE) * Counseling and program planning * Complementary Components 1. Math Skills 2. Science Foundations 3. University General Education Requirements	Students majoring in Elementary Education complete 6-8 credits of prescribed coursework. These include: El. Ed. 100 Orientation to Elementary Ed. FHD 150 Human Growth and Development, or Psy 110 Human Growth and Development. Prior to Level III, students must take math and science general education courses.	* Students are aware of the basic needs of children. * Students are exposed to the general requirements of the teaching profession. * Students are aware of program requirements. * Students have a common background in science and mathematics. * Students evaluate the decision to become a teacher in terms of "self".

Figure 2 - Self Component Input - Process - Output Description

Level II, Others, is represented by the "O" in the acronym SODIA. In this bloc, students receive 15 credits and are assigned to one of the cooperating public schools. The students spend approximately one-half of each day in classrooms working with teachers and children as a tutors and

aides. The remainder of the time is spent in seminars and classwork which are offered at the portal schools and on the USU campus. The classwork is interdisciplinary in nature. Students receive credit for Educatonal Psychology, Education of the Exceptional Child, Foundation Studies in Teaching, and Practicum in Elementary Education. (Students in Early Childhood Education also take the Seminar in Early Childhood Education and a Practicum in Early Childhood Education.) Entrance to Level II requires prior admission to Teacher Education and a 2.5 grade point average.

INPUTS	PROCESS	OUTPUTS
	Level II Others 1.2	
* 190 Students per year * 5 Faculty (FTE) * Cooperating schools * Cooperating teachers * Counseling & Program Planning	Students take fifteen credits as a one-quarter block of coursework. These courses include: El Ed 301 Foundation Studies in Teaching, El Ed 286 Practicum in Elementary Education, Psy 366 Educational Psychology for Teachers, and Education of Exceptional Children. Prior to Level III, students take El Ed 415 Teaching Reading, Math 201-202-203, El Ed 401, Science Methods, and science general education requirements: Biology 101, Geology 101, Physics 120, and Chemistry 101.	* Students become more familiar with "others" in the public schools. These include: teachers, administrators, and children, including multicultural education. * Students work directly in elementary classrooms. * Students utilize seminars to explore the realm of teaching. * Students demonstrate a basic understanding of the principles & processes of learning.

Figure 3 - Others Component Input - Process - Output Description

Level III, Disciplines, is represented by the "D" in the acronym SODIA. Students in this bloc receive 18 credits and are assigned to classroom and seminar experiences at the Edith Bowen Laboratory School on

the USU campus. The "methods" courses in reading, social studies, language arts, science, and mathematics are included in this bloc. Students diagnose, prescribe, teach, evaluate, and reteach in all the five subject matter areas. They also develop a variety of methods and approaches using diagnostic and prescriptive techniques.

INPUTS	PROCESS	OUTPUT
	Level III Disciplines 1.3	
* 180 Students per year * 5 Faculty (FTE) * Edith Bowen School * Cooperating Teachers * Elementary Students * Counseling and Program Planning	Students take fifteen credits as a one-quarter block of coursework. These courses include: El Ed 415, Teaching Language Arts, El Ed 416, Reading, El Ed 420, Teaching Social Studies, El Ed 430, Teaching Mathematics, and El Ed 386, Practicum in Elem. Educ. Methods courses are complemented by approximately equal time in elementary classrooms in Edith Bowen Laboratory School.	* Students demonstrate basic understanding of methods and materials for teaching mathematics, reading, social studies, and language arts. * Students plan, teach, and evaluate personal teaching experience in all areas of the curriculum.

Figure 4 - Disciplines Component Input - Process - Output Description

Level IV, Implementation, is represented by the "I" in SODIA. This is the student teaching phase of the program. Student teaching constitutes a full day of actual teaching experience for the full quarter. Student teachers are assigned to classrooms in public schools. Internships are for a full academic year. Interns work with a master teacher and receive 5/8 salary for a full academic year.

To better qualify and prepare the student teacher to teach grades one through six and provide indepth understanding of the total elementary program, the student teaching quarter is devided into two time blocs. For one bloc, the student teacher may be placed in either a primary or

intermediate grade; and in the next bloc the student teacher is placed in a different class on a different grade level. Such assignments may vary and are based on the interests and individual needs of student teachers.

INPUTS	PROCESS	OUTPUTS
	Level IV Implementation 1-4	
* 175 Students per year * 5 Faculty (FTE) * Cooperating Schools * Cooperating Teachers	* Students take a block of 15 credits. * These include El Ed 450 Elementary Curriculum Seminar, and El Ed 460 Student Teaching in Elementary Schools. * Students teach under the supervision and guidance of experienced teachers and university faculty.	* Students possess an indepth understanding of the total elementary program.

Figure 5 - Implementation Component Input - Process - Output Description

Level V, Associate Teaching, is represented by the "A: in the acronym SODIA. Associate teaching is optional and is an individualized program for senior students who have successfully completed their student teaching and who wish additional experience in the schools. The associate teaching level of the program permits students to make special arrangements to earn from 3 to 12 credits for additional work in an elementary school classroom. At their option, students may:

1. Pursue special interests, such as science or math;
2. Strengthen areas of weakness;
3. Perform almost any desired function in a regular school situation.

Associate teachers function as full-fledged members of the teaching team under the direct supervision of the cooperating teacher.

Rationale for a New Science Methods Course and Required Content Course

Both students and faculty have consistently reported that the Level III term placed very heavy demands upon the student. Over the years, various concessions have been made to accommodate a reasonable balance between methods course requirements and practicum experiences. The most visible accommodation was a reduction in the number of contact hours devoted to the 15 credits of methods courses. This reduction was justified on the basis that students experience a major component of methods experience in the accompanying practicum. In the case of science, this was not a valid assertion. Some students reported not being able to teach any science in their practicum due to peculiarities of classrooms to which they were assigned.

To compensate for perceived science contact hour deficiencies, the classroom time for the science course was expanded to more nearly match that of an on-campus three-credit course. Even with the increased time, students consistently indicated they wanted more time in science methods, and evaluated the science methods course highly.

General national and state concern (National Science Board, 1983, Milne, 1983; Daugs, 1983) about the science competencies of elementary teachers led to meetings between College of Science and College of Education faculty. A USU Science Education Advisory Group was initiated in 1983. The group included the dean of education, the dean of science, two science educators, and biology, chemistry, geology and physics department heads. The actions of this advisory group resulted in a proposal to change the science requirements for elementary teachers and develop a new science methods course. The proposed changes met or exceeded the NSTA recommendations for certification of elementary teachers (NSTA, 1983).

The advisory group proposed that science methods be prerequisite to

the Level III block. It was reasoned that the new course would supply an intermediate step in classroom exposure between Level II and Level III with a science-only teaching practicum as part of the course. This requirement would also assure a more uniform student exposure to science teaching than previously existed.

Early research (Beryyessa, 1959; Lamors; 1949; Lerrer, 1957, Rutledge, 1957; Wishart, 1961) revealed a positive correlation between science background and various teaching competencies. More recently research indicates (De Rose, 1979; Fitch, 1979) that many elementary teachers feel unqualified to teach science because of their poor science content background.

Although there appears to be almost universal agreement that elementary school teachers should have a good science foundation, few colleges and universities have matched research findings with content offerings. Many science educators (Blosser, 1969; McDermott, 1976; Rowe, 1978; Suchman, 1976; Victor, 1974) also believe that process oriented elementary teachers should be knowledgeable about the concepts and conceptual schemes that emerge as science inquiry progresses. Only one-third of the institutions surveyed by Stedman (1982) design their science content courses to meet the needs of elementary teachers. AAAS guidelines (AAAS, 1970) indicate there should be a match between science topics that are taught to teachers and the science topics that are taught to children. In accordance with the above guidelines, the Advisory Group recommended changes in the content offerings for Utah State University elementary education majors. Four required science content courses were revised to cover all the components of the Utah Elementary Science Core.

CURRICULUM FRAMEWORK

Figure 1 illustrated all components of the SODIA program. Component 1.3, Disciplines, included the science methods course. Figure 6 illustrates the configuration of the Disciplines component, with the science methods course as a prerequisite to the Level III block.

Level III, Disciplines

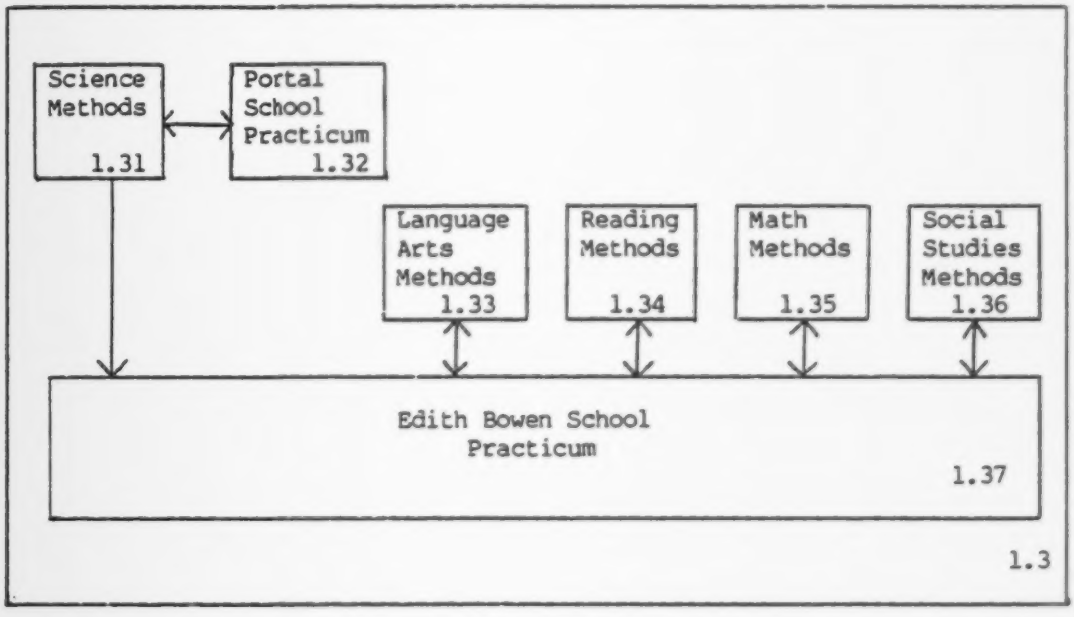
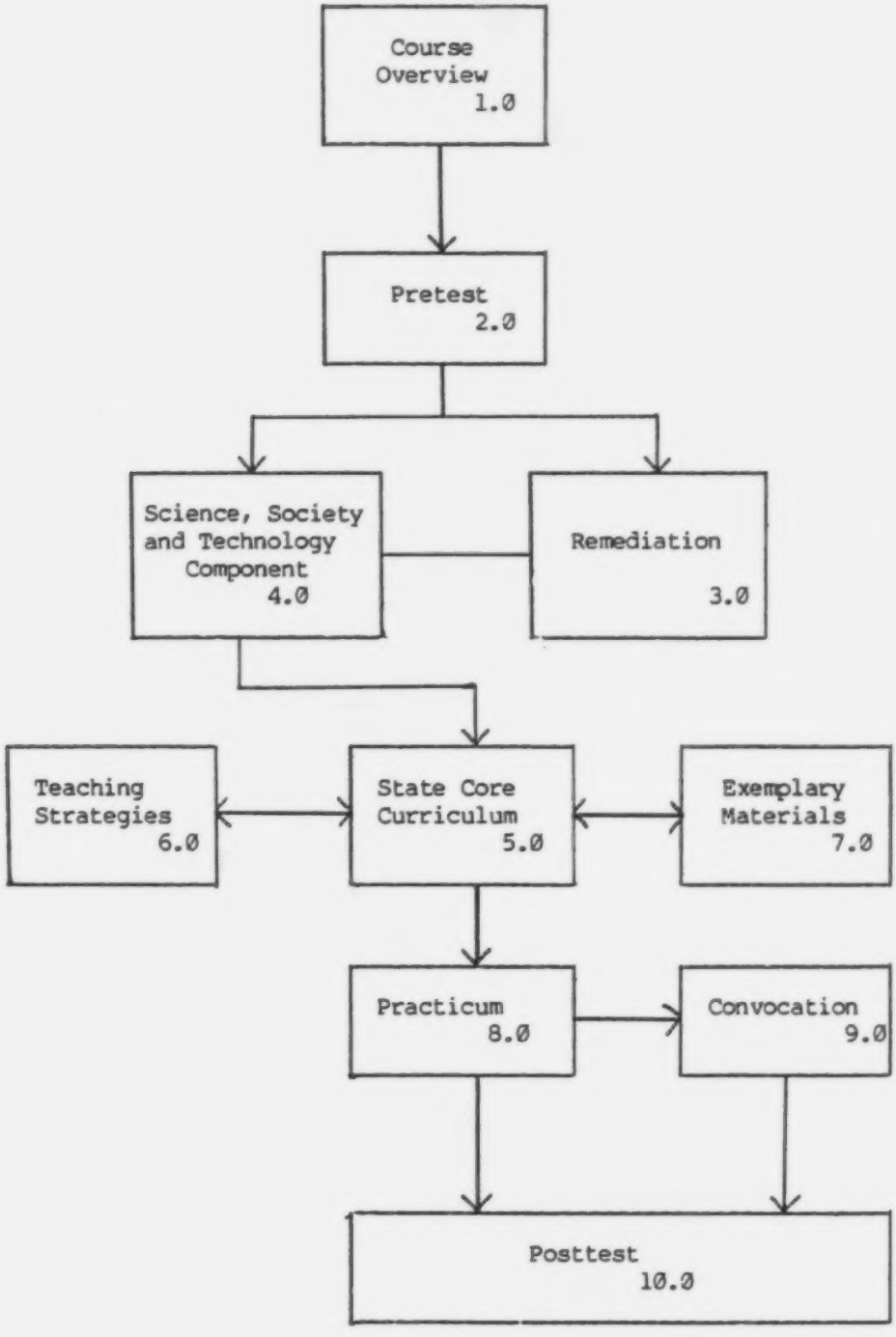


Figure 6, Level III, Disciplines Components

The methods course is organized around ten basic components as identified in Figure 7, a composite flowchart.

Figure 7
El. Ed. 401 Science Methods (5 cr.)
Component Flowchart



Curriculum goals and objectives for each component are presented in the section that follows in the form of a conceptual framework. The framework lists the major goals and objectives upon which the content and activities of the new course will be based. The framework will serve as an organizational tool for developing the course, and as a basis of first level evaluation.

Program Goal 1.0 **To provide an overview and outline of course requirements and procedures.**

Topic 1.1 Course Outline

Objectives: The student should:

1.11 be familiar with the components of the course.

Topic 1.2 Requirements and Grading

Objectives: The student should:

1.21 be aware of course requirements and options for achieving them.

1.22 understand grading procedures for all components of the course.

Topic 1.3 Recordkeeping.

Objectives: The student should:

1.31 be able to utilize computer managed record keeping procedures for the purpose of demonstrating progression within the course.

Program Goal 2.0 **To provide a means of determining student level of scientific literacy.**

Topic 2.1 Content Area Assessment

Objectives: The student must:

2.11 achieve a score of at least 80% in each of four (biology, geology, earth science, physics) content area assessments.

Topic 2.2 Science Process Skills Assessment

Objectives: The student must:

2.21 achieve a score of at least 80% on a comprehensive science process skill assessment.

Topic 2.3 Science Attitude Assessment

Objectives: The student must:

2.31 Attain a score of at least 80% on an attitude toward science assessment.

Program Goal 3.0 To facilitate, in a variety of ways, remediation of deficiencies identified in pretest procedures.

Topic 3.1 Biological Science Deficiencies

Objectives: The student who is below criterion in 2.1 must:

3.11 Enroll in or audit existing biology courses to improve competencies in biology.

3.12 Utilize a computer mediated instructional program to improve competencies in biology.

3.13 Arrange an individualized remedial program with a faculty member.

3.14 Propose and have approved by the course instructor, a student designed remedial program.

Topic 3.2 Geology Deficiencies

Objectives: The student who is below criterion in 2.1 must:

3.21 Enroll in or audit existing earth science courses to improve competencies in earth science.

3.22 Utilize a computer mediated instructional program to improve competencies in earth science.

3.23 Arrange an individualized remedial program with a faculty member.

3.24 Propose and have approved by the course instructor, a student designed remedial program.

Topic 3.3 Chemistry Deficiencies

Objectives: The student who is below criterion in 2.1 must:

3.31 Enroll in or audit existing chemistry courses to improve competencies in chemistry.

3.32 Utilize a computer mediated instructional program to improve competencies in chemistry.

3.33 Arrange an individualized remedial program with a faculty member.

3.34 Propose and have approved by the course instructor, a student designed remedial program.

Topic 3.4 Physics Deficiencies

Objectives: The student who is below criterion in 2.1 must:

3.41 Enroll in or audit existing physics courses to improve competencies in physics.

3.42 Utilize a computer mediated instructional program to improve competencies in physics.

3.43 Arrange an individualized remedial program with a faculty member.

3.44 Propose and have approved by the course instructor, a student designed remedial program.

Topic 3.5 Science Process Skill Deficiencies

Objectives: The student who is below criterion in 2.2 must:

3.51 utilize appropriate instructor specified exercises in prescribed sources to improve science process skills.

3.52 attend and participate in scheduled science process skill improvement sessions.

Topic 3.6 Attitude Toward Science

Objectives: The student who is below criterion in 2.3 should:

3.61 review with the instructor any attitudes identified in the pretest that contributed to a low score.

3.62 discuss, on a one-to-one basis with the instructor, possible implications of attitude toward science on future science teaching.

3.63 devise a personalized plan and set goals to improve attitude toward science.

3.64 participate in science-math anxiety alleviation experiences.

Program Goal 4.0 **To provide a fundamental understanding of science and technology, in order for teachers to better make informed decisions related to science and technology interactions with society.**

Topic 4.1 Science and Technology

Objectives: The student should:

4.11 compare and contrast science and technology.

4.12 appreciate how science and technology contribute to new knowlege.

Topic 4.2 Impacts on Society

Objectives: The student should:

4.21 examine past and present examples of the impact science and technology have had on society, economic growth, and the political process.

4.22 infer global perspectives on the interrelationships among science, society, and technology.

Topic 4.3 Practical Applications

Objectives: The student should:

4.31 examine issues that relate to their lives, their families and communities, and that emphasize themes of broader significance.

4.32 focus on one or more problems that can be examined in a scientific manner.

4.33 utilize decision making strategies to answer the question, "What can we really do?"

4.34 conduct a science, society, and technology-oriented personal investigation.

Program Goal 5.0 **To provide background on the origin and requirements of the Utah Elementary Science Core.**

Topic 5.1 Elementary Science Core Overview

Objectives: The student should:

5.11 be familiar with the State Core numbering system in order to

use it as an aid in a computer-managed curriculum.

5.12 be familiar with the heirachial arrangement of standards and objectives as stated in the Utah State Science Core.

5.13 examine across-the-curriculum relationships as presented in the Utah Elementary Science Resource Guide.

5.14 identify and explain how all aspects of the Utah Elementary Science Resource Guide relate to the State Elementary Science Core.

Program Goal 6.0 **To apply teaching principles, skills, and methods to teaching elementary science.**

Topic 6.1 Scientific Literacy

Objectives: The student should:

6.11 be able to define scientific literacy.

6.12 identify and/or devise lesson plans that promote improvement in scientific literacy.

6.13 identify and/or devise means of assessing student levels of scientific literacy.

Topic 6.2 Cognitive Processes

Objectives: The student should:

6.21 know and apply principles of cognitive psychology to teaching elementary science.

Topic 6.3 Multidisciplinary aspects.

Objectives: The student should:

6.31 be able to relate science objectives to goals and objectives in other subject matter areas at the same grade level.

6.32 be able to identify and/or plan science lessons that integrate other subject matter areas with science.

Topic 6.4 Laboratory Techniques and Equipment

Objectives: The student should:

6.41 be familiar with laboratory equipment commonly used in elementary science programs.

6.42 be aware of hazards and safety precautions associated with elementary science laboratory work.

Program Goal 7.0 **To familiarize students with exemplary elementary science curricula.**

Topic 7.1 Industry and Nonprofit Organization-Produced Curricula.

Objectives: The student should:

7.11 be able to describe the major features of Project Learning Tree, Project Wild, Water Education K-6, and Energy and Man's Environment materials.

Topic 7.2 Publisher-Produced Curricula.

Objectives: The student should:

7.21 be able to describe the major features of one or more publisher produced elementary science textbook series.

7.22 be able to describe the major features of one or more publisher produced elementary science lab-approach curricula.

Topic 7.3 Supplementary Materials and Journals

Objectives: The student should:

7.31 be familiar with Science and Children, Science Scope, and similar publications.

7.32 be familiar with a variety of publisher produced science teaching aids.

Program Goal 8.0 **To provide the opportunity for students to teach a series of science lessons in an elementary or middle school classroom.**

Topic 8.1 Practicum

Objectives: The student should:

8.11 contact a cooperating teacher and make plans to teach three or more science lessons.

8.12 submit appropriate lesson plans to the cooperating teacher for approval prior to teaching.

8.13 teach three or more science lessons in an elementary or middle school classroom.

8.14 submit lesson plans, a personal evaluation, and the cooperating teachers' evaluation to the instructor for final evaluation.

Program Goal 9.0 **To provide a culminating experience that demonstrates science and teaching competencies. (OPTIONAL)**

Topic 9.1 Convocation

Objectives: The student should:

9.11 plan and make arrangements for a special science learning experience for a small group of children.

9.12 conduct a science convocation.

Program Goal 10.0 To provide a means of measuring growth and exit level of performance.

Topic 10.1 Posttest

Objectives: The student should:

10.11 demonstrate mastery of course objectives in accordance with prescribed criteria levels.

COMPONENT I, P, O'S

The section that follows presents I, P, O's for each topic listed in the curriculum framework.

INPUTS	PROCESS	OUTPUTS
	Topic 1.1 Course Outline	
* Students * Printed Course outline * Classroom to seat 50	The instructor provides a verbal and written description of the course. Time 15 min.	* Students will have an understanding of course goals, objectives and procedures.
	Topic 1.2 Requirements & Grading	
* Students * Printed Course Requirements *Instructor	The instructor provides a verbal and written explanation of course requirements and grading procedures. Time 15 min.	* Students will be aware of course requirements and options for achieving them. * Students will understand grading procedures for all components of the course.
	Topic 1.3 Record Keeping	
* Students in groups of 12 * Computer terminal * one floppy disc per student	The instructor will explain and demonstrate how the computer will be used for testing, instruction, and record keeping. Each student will initiate their own computer file for the course. Time 30 min each group.	* Students will demonstrate ability to use the computer to manage record keeping for their progress in the course.

Figure 8 - Program Goal 1.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topic 2.1 Content Area Assessment	
* Students * Personal Record Disc * Computer Terminal * Content Area Assessment Disc	Students will utilize a computer-mediated assessment procedure to self-preasseas content area competencies in biology, geology, chemistry, and physics. Time: TBA	* Students performing at below the 80% level will be identified.
	Topic 2.2 Science Process Skill Assessment	
* Students * Personal Record Discs * Computer Terminal * Process Skills Assessment Disc	Students will utilize a computer-mediated assessment procedure to self-preassess science process skills competencies. Time: TBA	* Students performing below the 80% level will be identified.
	Topic 2.3 Science Attitude Assessment	
* Students * Personal Record Disc * Computer Terminal * Science Attitude Assessment Disc	Students will utilize a computer-mediated assessment procedure to self preassess attitude toward science Time : TBA	* Students performing below the 80% level will be identified.

Figure 9 - Program Goal 2.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topics 3.1 - 3.4 Content Area Deficiencies	
* Students with pretest scores of less than 80% * Science content courses * Science faculty * Instructor * Computer terminal * Personal record disc * Content area assessment disc	Existing content courses, computer-mediated instruction, science faculty, or other resources will be available for students to improve their content background in the sciences. Students must achieve 80% level of competency on a retest. Time: TBA	* Student performance of at least the 80% competency level in all four science content areas.
	Topic 3.5 Science Process Skill Deficiencies	
* Students with pretest scores of less than 80% * A variety of self instructional procedures * Access to lab facilities * Instructor * Science process skill lecture-lab. * Computer terminal * Personal record disc * Process skills assessment disc	Students will utilize prescribed learning strategies designed to improve competencies in specific science process skills. Strategies will be written out so that they can be followed as self-instructional procedures in the lab. Alternatively students may attend an instructor guided lecture-lab designed to improve science process skills. Students must attain an 80% level of competency on a retest. Time: 3 hrs. Optional for those students with demonstrated competency.	* Student performance on at least the 80% competency level on the science process skills assessment instrument.

Figure 10 - Program Goal 3.0 I-P-O Description

INPUTS	PROCESS	OUTPUTS
	Topic 3.6 Attitude Toward Science	
* Students with pre-tests scores of less than 80% * Instructor * Science-math anxiety seminars	Students meet with the instructor on a one-to-one basis and discuss any attitudes identified in the pretest that contributed to a low score. The instructor will relate attitude deficiencies to possible implications for future science teaching. Students will devise a mutually agreed upon personal plan to improve science attitude and/or attend a science-math anxiety alleviation seminar. Time: TBA	* Students will be aware of factors influencing their attitudes toward science score. * Students will infer possible impact of attitude on ability to teach science. * Students may carry out procedures designed to improve attitudes toward science.

Fig. 10 (continued) Program Goal 3.0 I-P-O Description

INPUTS	PROCESS	OUTPUTS
	Topic 4.1 Science and Technology	
* All students * Classroom * Video facilities * Video cassette	A video presentation will be used to provide background on the differences between science and technology. The presentation will depict how science and technology create new knowledge and new problems. Time: 1 hour	* Students will be aware of differences between science and technology. * Students will appreciate how science and technology contribute to new knowledge.
	Topic 4.2 Impacts on Society	
* All Students * Classroom * Video facilities	A series of video presentations will be used to provide a broad perspective on past and present impacts of science and technology on society, economic growth, and political process. Time: 2 hours	* Students will appreciate the impact of science and technology on society, economics, and politics. * Students will infer the need for a global perspective when considering STS issues.
	Topic 4.3 Practical Applications	
* All students * Science Faculty	In a lecture-discussion situation students will explore STS issues that have local relevance. These sessions will be conducted by science faculty. Case studies will be used to illustrate how issues can be examined in a scientific manner. Students will conduct an individualized STS investigation. Time: 8 hrs.	* Students will have an an increased awareness of science-society-technology interactions. * Students will relate STS issues to self, family, and community * Students will infer that STS issues lend themselves to scientific solutions. * Students will use various decision making strategies to answer the question "What can we really do?"

Figure 11 - Program Goal 4.0 I-P-O Descriptions

INPUT	PROCESS	OUTPUTS
	Topic 5.1 Elementary Science Core Overview	
* All students * Instructor * Classroom * State Science Core * Utah Elementary Science Resource Guide discs * Apple IIe Computers/ printers	In a lecture-discussion situation the instructor will introduce the students to the Utah Elementary Science Core. The Apple IIe computer will be used to introduce the Utah Elementary Science Resource Guide. The instructor will explain how the guide is tied to the Core and how the various aspects of the guide relate to the total elementary curriculum.	* Students will be aware of the numbering system, heirarchical arrangement of standards and objectives, and general content of the Utah Elementary Science Core. * Students will understand how the Utah Elementary Science Resource Guide is tied to the Core curriculum.

Figure 12 - Program Goal 5.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topic 6.1 Scientific Literacy	
* All students * Instructor	A reading will be used to introduce the concept of scientific literacy.	* Students will be able to define scientific literacy.
* Utah Elementary Science Resource Guide Discs	The Utah Elementary Science Resource Guide will be used to illustrate various plans and procedures for increasing and assessing levels of scientific literacy.	* Students will be able to recognize examples of lessons that develop comprehension, application, and attitude components of scientific literacy. * Students will be able to identify and devise assessment items that measure various aspects of scientific literacy.
	Time: 1 hour	
	Topic 6.2 Cognitive Processes	
* All students * Textbook examples * Laboratory facilities * Instructor	Readings will provide a review of Piagetian principles of cognitive psychology. These principles will be related to elementary science classroom experiences that students may read about and actually carry out in the laboratory if they so desire.	* Students will understand potential implications of cognitive psychology for teaching science. * Students will relate Piagetian stages of development to specific types of science activities.
	Time: TBA	
	Topic 6.3 Multidisciplinary Aspect	
* All students * Classroom * Instructor * Elementary Science Resource Guide	The instructor will model a number of examples tying science to other parts of the elementary curriculum.	* Students should relate science objectives and goals to goals and objectives in other subject matter areas at the same grade level. * Students should be able to apply principles learned in this component to practicum and/or convocation experiences.
	Time: 1 hour	

Figure 13 - Program Goal 6.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topic 6.4 Laboratory Techniques and Equipment	
* Students * Instructor * Equipment lists * Station studies/ equipment * Lab safety manuals	Students will follow self-instructional procedures to familiarize themselves with common elementary science equipment and procedures. These learning experiences will be set up in stations with instructional strategies, equipment, and lab safety references.	Students should be familiar with laboratory equipment commonly used in elementary science programs. Students should be aware of hazards and safety precautions associated with elementary science laboratory work.

Figure 13 (Continued) - Program Goal 6.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topic 7.1 Industry or Non-Profit Organization Produced Curriculum	
* All students * Instructor * Classroom sets: Project Learning Tree Project Wild, Water Education K-6, Energy and Man's Environment, and People and Animals. * Analysis strategies	Students will follow a prescribed procedure to evaluate one or more sets of curriculum materials. Time: TBA	* Students should identify the desirable and undesirable aspects of industry or nonprofit organization produced curriculum materials. * Students should identify potentially undesirable aspects of biased materials.
	Topic 7.2 Publisher Produced Material	
* All Students * Instructor * Classroom sets of most commonly used textbook series. * Classroom sets of lab approach curricula.	Students will follow a prescribed procedure to evaluate one or more textbook approach curricula and one or more lab approach curricula. Time: TBA	* Students should identify the desirable and undesirable aspects of publisher producer curricula. * Students should be able to identify and describe materials that match various teaching approaches.

Figure 14 - Program Goal 7.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	Topic 8.1 Practicum	
* All students * Instructor * Portal Schools * Cooperating Teachers * Teaching contracts and evaluation document	This component is designed to give the student an opportunity to teach a series of science lessons in an elementary or middle school classroom. Each student will be assigned to a cooperating portal school teacher. The student will meet with the teacher and arrange a teaching contract. The contract will specify when, where, and what is to be taught. Prior to teaching, the student will submit lesson plans for cooperating teacher approval. The instructor will serve as a resource person as needed. Students will submit lesson plans, cooperating teacher evaluations, and a personal evaluation to the instructor upon completion of the practicum. Time: TBA	* Students should demonstrate professionalism in dealing with cooperating teachers, principals, and students. * Students should demonstrate ablity to plan effectively. * Students should teach three or more science lessons. * Students should provide self-evaluations.

Figure 15 - Program Goal 8.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	9.1 Convocation	
* Any students desiring this experience. * Instructor * Science Faculty * Resource Persons * Classrooms * Various science equipment.	This component is provided as an opportunity for students to demonstrate mastery of science and science teaching. The idea of a convocation is to bring together gifted children and science people, with the student coordinating the special learning experience. The student should originate the idea, discuss and plan the session with the help of the instructor, make all arrangements for the session, and carry out the convocation. In most cases, the convocations will be held on Saturdays. Students will submit a summary of the experience to instructor. The summary will include participant and peer evaluations. Time: TBA	* Students should demonstrate ability to work with a variety of people. * Students should be able to plan effectively. * Students should make appropriate space, equipment and people arrangements. * Students should conduct the convocation in a professional manner.

Figure 16 - Program Goal 9.0 I-P-O Descriptions

INPUTS	PROCESS	OUTPUTS
	10.0 Post Test	
* All students * Instructor * Personal record disc * Computer facilities	All students will be administered a posttest that covers all aspects of the course. Students will be assigned grades in accordance with criteria specifics under "Grading".	* Students will obtain a test score that indicates competency to teach science.

Figure 17 - Program Goal 10.0 I-P-O Descriptions

Justification by Goal and Topic

The section that follows will provide some philosophical and/or research justification for each component of the methods course. Though not exhaustive, comments are included for each Program Goal, with more or less detail for each topic, as appropriate.

Program Goal 1.0

The topics under Program Goal 1.0 were designed to provide an overview of the course and to outline course requirements and procedures. It was inferred from research findings that a high anxiety level generally accompanies poor student performance (Gandry & Spielberger, 1971). The general purpose of topics under Goal 1 is to alleviate anxiety by providing an understanding of what will be required in the course.

Topic 1.1

Karzwell (1968) suggested that building student trust may reduce anxiety and promote better science teaching. Trust is increased when there is a common understanding of events and expectations. Therefore, it is desirable at the outset of a course that students be aware of what will be involved in the course.

McCaulley (1976) studied the distribution of the various learning "types" among students and teachers at various school levels. He found that there were three areas of preference:

(1) Those that prefer to learn by direct immersion in activities, followed by a period of more abstract review.

(2) Those that preferred to be given a picture of the place of the activity in the whole.

(3) Those that preferred to go off in unexpected directions.

One of the major purposes of the course outline is to show that all three

of the above options are a part of the course.

Topic 1.2

The reward system, as demonstrated most openly by grades, is perhaps the greatest source of anxiety and mediator of attitude. Evans (1976) concluded that grading does not fulfill its purported functions and can produce undesirable motivational effects. The negative effects of external rewards were well described by Deci (1975). Grading is particularly sensitive in the instance of the science methods course in that the grading philosophy of the course is not that of the department. Departmental policy is that each course have as a grade goal an average GPA of 3.2.

Justification for alternatives to the externally imposed GPA goal of 3.2 are not easily documented. Simon and Bellanca (1965) reviewed grading practices. The basic issues revolve around normative concerns versus developmental concerns. If the research about cognitive development is taken into account, it can be concluded that grading practices based upon individual development, rather than those which judge students in comparison to one another, would be more appropriate. Students should be given the grade they earn.

It was considered important that the grading procedure be consistent with the philosophy of meeting individual needs through individualized curriculum. Mutual understanding of course goals, application of evaluation processes and instruments consistent with goals, and student teacher discussion of grading policy should reduce some of the undesirable effects of grading (Robinson, 1979). This topic is further discussed under Program Goal 10.0.

Topic 1.3

The third topic under Goal 1.0, record keeping, will familiarize

students with computer recordkeeping procedures. The computer assisted instruction (CAI) component of the methods course will be used for testing and monitoring of performance.

This concept also applies specifically to elementary teachers. As utilized in the methods course, computers will give the student practical application of computers for future classroom use. If teachers are to utilize these technologies with students, then they must fully understand the technology (Eastman, 1984; Eastman and Agostino, 1984).

Program Goal 2.0

Topic 2.1, 2.2, 2.3

Scientific literacy, as discussed in detail under Goal 6.0, is a major objective of most science programs. For the purposes of the new methods course, scientific literacy consists of three measurable components: content background, science process skills, and attitudes. Accordingly, assessment instruments have been developed to measure these components. The instruments are modeled after the 1982 British Columbia Science Assessment (Taylor, 1982).

Content validity was determined by having approximately 175 elementary teachers, that had been trained as elementary science teacher-leaders, review potential items and select out any that they felt were not appropriate for elementary teachers.

Test development is not complete at this time.

The major purpose of preassessment is to identify need for individual remediation.

The 80% competency level on pretests was set arbitrarily. In all literature reviewed by Robinson (1979), the criterion of "minimum competency level" was, in the final analysis, arbitrary. The concept of

minimum competency is in tune with Utah State Office of Education policy on Core Curriculum standards for all students. In correlating the preassessment with the State Elementary Science Core (1984), an attempt was made to realistically base all teacher competencies on a foundation of skills and knowledges found in the core. Thus, the minimum expectations for prospective teachers is that they have the performance level expected of their students. This approach rests on the assumption that minimal levels can be specified (Glass, 1976). Much controversy has existed over the issue of ability to measure competency levels. For the purposes of this course, performance levels are indicators based upon stated educational objectives.

One bias was intentionally built into the assessment instrument. The nature of science-attitude component was intentionally designed to produce high scores. It was inferred that if attutude toward science had an overriding influence on the other components of scientific literacy, then the person who scored poorly on a content or skills component might be more inclined to cope with remediation if testing indicated the person had a good attitude toward science.

An additional reason for designing the attitude test for high performance was that the course developers were not sure of how best to remediate deficiencies. Gould (1982) challenged the long standing goal that development of the scientific attitude in the form generally conceived should even be attempted. A variety of evidence demonstrated that the empiricist conception of scientific attitudes was untenable and produced a false image to which students are molded.

Program Goal 3.0

Topics 3.1, 3.2, 3.3, 3.4

The remediation of deficiencies identified in pretesting was

considered critical to progress in the course. The foundation of a common core of knowledge and skills was set as a prerequisite to progress in the course. Students not performing at acceptable levels on the preassessment must select and carry out appropriate remediation. Remediation could include taking or retaking an appropriate science course; auditing a course; independently seeking tutorial help; using an interactive videodisc; attending regularly scheduled remediation sessions; or, devising any other appropriate plans. In any case, no student would move to the other components of the methods course until minimum content and skill competencies were demonstrated. This requirement dictated flexible course completion times. Students with deficiencies would require greater time to complete the course.

The development and use of the videodisc for instructional purposes is in its infancy. The status of this technology is summarized by Hofmeister (1985). The purpose of including this component as a possible means of remediation is twofold: remediation and utilization of this technology as a delivery system for course content. Initial use will be for chemistry only.

The moderating effect of individual differences on learning is well documented in the literature. However, the extent to which the differences can be accommodated in instruction is not so well documented. Hallada (1982) examined the effect of mastery instruction among college students. After identifying 50 of the 350 subjects as underprepared for college chemistry, the subjects were assigned to a system of instruction which incorporated mastery learning principles. Their performance was compared to 300 subjects exposed to regular chemistry instuction. A finding of no significant difference in performance was treated as a positive treatment

effect.

McKenzie (1985) investigated the use of diagnostic testing in a science course designed for elementary teachers. This research suggested that use of computer-based diagnostic instruction does not enhance achievement in a laboratory component of a general science course. Although performance of the experimental groups was not statistically higher than the control groups, scores were higher, and students perceived the use of the computers as valuable.

Work by Thompson (1980) and Kelley (1973) formed a basis for justifying an individualized component to the methods courses. Mott (1980) summarized the merits of initial investments of development time to develop individualized programs as related to student performance and attitudes.

Consistent with the concept of individualization of the curriculum, alternative modes of remediation were developed. For each content area, these alternatives include:

(1) Enroll in or audit existing courses;

(2) Utilize a computer-mediated instructional program;

(3) Arrange an individualized remedial program with a faculty member;

(4) Propose some other alternative approach;

The primary responsibility for remediation rests with the student. The course instructor is a facilitator in the spirit of the "helping relationship".

Remediation of science process skills deficiencies has been a component of the previous science methods course for some time. Most science methods course texts provide ample experience in developing specified skills.

Program Goal 4.0

Topic 4.1, 4.2, 4.3

Though there are society and technology components in the four required science content courses, the issue of science, technology, and society (STS) is neither fully addressed in these courses nor is it related to the elementary school curriculum. Therefore, it was considered advisable to add a major STS component to the science methods course.

The emphasis of the STS component deals primarily with the interface of science, technology, and society. For the purpose of this course, technology is defined as the hardware developed for use by people. This ranges from hammers to computers. Technology also includes systems used to solve problems and influence behavior as well as human actions such as wiring a lamp or changing a tire.

The status of STS teaching was summarized by Piel (1981). His findings lead to the conclusion that as our society has become more technologically oriented, our science curriculum has become less so. The inclusion of the STS component in the methods course should help remedy this deficiency for our students.

Program Goal 5.0

Topic 5.1

Classroom experiences in the science methods course are organized to familiarize the student with a variety of curriculum components, including the Utah Core Curriculum, hierarchial arrangement of standards and objectives, computer mediated curriculum management, science lesson plans, textbook correlation, integration of the total elementary curriculum extensions, and gifted and talented applications. The Utah State Core consists of a set of standards and objectives, arranged by grade level. This framework has been keyed to a numbering system and expanded into a

computer-mediated curriculum retrieval system. There was no research justification for inclusion of this component in the methods course. The Core is a reality, externally imposed by the Utah Board of Education. Inclusion in the methods course is justified from the standpoint of practicality.

Program Goal 6.0

Program Goal 6.0, applying teaching principles, skills, and methods to teaching elementary science, is a many faceted course component. Each component can be justified as important, but the grouping of topics and order of presentation is arbitrary.

Topic 6.1

Scientific literacy is a stated objective of most elementary science programs. However, the term is most often not defined. The phrase "scientific literacy" seems to have originated in the 1950's as a rallying cry for science education improvement (Fitzpatric, 1960; Hurd, 1958; Waterman, 1958).

The alphabet soup (BSCS, PSSC, etc.) curriculum reforms of the 1960's apparently did not have scientific literacy of the general public as a top priority. They really did not build on the rallying cry of the 1950's. Lawrence Gabel (1965) and Milton Pella (1966a) generated composite definitions of scientific literacy. The time period 1966-1975 was characterized by considerable activity to further interpret the term scientific literacy. At least 18 different interpretations were published in various journals. Overwhelmingly, the emphasis was to define scientific literacy as basically an either-or-competency (Evans, 1970; Hurd, 1963, and Pella, 1966b).

If, as Koshland (1985) suggests, there is a major gap between

scientist and non-scientist, then the analysis of the gap must be made in some meaningful framework. The most recent detailed analysis of the situation was summarized by Graubard (1983) in a recent issue of Daedalus:

> Even the most casual examination of this issue of Daedalus will suggest that the term scientific literacy lacks all precision, that there are no generally accepted criteria for determining what an individual needs to know to be called scientifically literate. . .

A dilemma in the process thus far reported is that it is very difficult to develop curriculum from such comprehensive frameworks. Another criticism is that most efforts have been backward looking, rather than forward looking. The basic underlying problem is that science, technology and society are not static. With this orientation to the past, subject matter and teaching objectives have presented science as a closed book. The element of change is largely missing.

The notable exception to this trend was initiated by Paul DeHart Hurd. In 1967, with sponsorship from the National Science Foundation, BSCS carried out a study of science teaching in middle and junior high schools. A Biological Science and Society Committee was formed. The end result was the Human Sciences Program that emerged in experimental form in 1974-75. Expository texts were replaced by activities that served the interests and concerns of emerging adolescents. The rationale for this process is summarized in The Status of Middle School and Junior High Science (Hurd et al., 1981).

Daugs (1970) stated a case for defining the term scientific literacy and for having a "workable" definition, one that does not categorize everyone as scientifically illiterate. It was inferred in that article that scientific literacy consisted of concept, comprehension, and application components. However, it is now felt that there are at least four components. The four components are concept level, comprehension

level, application level, and attitude level.

These components form the method course basis of the preassessment and are expanded upon in course component 6.1.

Topic 6.2

Course objective 6.21 reads, "The student should know and apply principles of cognitive psychology to teaching elementary science." Inherent in this statement is the assumption that students know something about cognitive psychology.

The volume of research on the Piagetian model of cognitive development indicates that preservice students should at least be exposed to some aspects of the model. Lawson (1982a, 1982b) makes a case for educator awareness and concern for assumed student reasoning abilities and summarizes the evidence to demonstrate the validity of studying the development of general cognitive operations. Accordingly, a small component of the course has been devoted to this topic.

Topic 6.3

Program Goal 6.3 reflects a philosophy that promotes teaching elementary science as an integrated part of the total elementary curriculum. Historically, the elementary science curricula of the 1960's were good science and were taught as science for science's sake. A tendency, first established by the Lippincott Elementary School Science Program and the Modular Activities in Programmed Science, to teach science in a multidisciplinary mode, is now reflected in many programs. Mishler (1982) recommended that science and language arts be integrated, based on evidence from studies that indicate science experiences enhance cognitive skill development and have positive effects on language arts skill development. Wellman (1978) reviewed educational research and demonstrated

a clear and positive relationship between science and language arts.

E. H. Moose (1903) long ago suggested that science and math be integrated "so that always students' mathematics should be directly connected with matters of throughly concrete character. . ."

It has been demonstrated by Almy (1970), Renner (1971), and Stafford (1969) that a child's level of thought influences achievement in mathematics. It can be inferred from these studies that there is at least an indirect relationship between science and mathematics.

Science can also promote creativity. Torrence (1962) included hypothesis forming as a part of creative thinking. Children involved in science activities also develop a reservoir of experiences that can be tapped through creative writing.

Much research has been reported on transfer of training related to the topic of integration of science with other disciplines (Thorndike & Woodworth, 1901; Judd, 1939; Bayles, 1960; Gagni, 1962; Cranbach, 1963; and Orata, 1941). Kern (1979) indicates there are three ways to integrate curriculum. The approach followed in the science methods course is what Kern terms a "fused curriculum in which the areas are taught as 'one'."

Research indicates that experience-based elementary science programs foster development of language and reading skills (Barufaldi and Swift, 1977). Wellman (1978) conducted research that indicates elementary science instruction can increase achievement scores in reading and language arts, and also offer alternative teaching strategies to motivate children with difficulties in these areas. In another study, Wellman also found evidence that science instruction improves reading skills in grades 4, 5, and 6:

> Some of the benefits that intermediate-grade children have been found to derive from science instruction are: vocabulary enrichment, increased verbal fluency, enhanced ability to think logically, and improved concept formation and communication skills.

Component 6.4, "Laboratory Techniques and Equipment" will familiarize students with the apparatus and potential hazards and safety precautions appropriate for elementary science.

Topic 6.4

In 1970, the case for lab science was presented by the NSTA Commission on Professional Standards and Practices as self-evident: "The time is surely past when science teachers must plead the case for school laboratories." Teacher unfamiliarity with laboratory equipment commonly used in conjunction with elementary science programs has contributed to lack of "hands on" science teaching. Bates (1978) summarized the research implications of lab work for secondary school science. Tentative conclusions from the research reviewed are these:

(1) Lecture, demonstration, and laboratory teaching methods appear equally effective in transmitting science content.

(2) Laboratory experiences are superior for providing students skills in working with equipment.

(3) Although most research has failed to assess outcomes that might be specific to the laboratory, meaningful laboratory measures can be developed; the laboratory appears to represent a significantly different area of science learning than content acquisition.

(4) Some kinds of inquiry-oriented laboratory activities appear better than lecture/demonstration or verification labs for teaching the process of inquiry. However, teachers need to be skilled in inquiry teaching methods; specific inquiry training should be provided over extended periods; and students need both time and guidance to become comfortable with the new methods and expectations.

(5) Laboratories appear to have potential for nurturing positive student attitudes and for providing a wider variety of students with opportunities to be successful in science.

All elementary teachers should have a basic understanding of hazards and safety precautions associated with laboratory work. This topic is discussed in the literature, but research evidence for inclusion as methods course component is lacking.

Topic 6.5

The recent call for science for all students, K-12, was a significant change in thinking. From 1950 to about 1974, attention was focused almost exclusively on the educational needs of students that would become scientists and engineers (AAAS, 1970). Science must be tied to the everyday world to have relevance for all students (Butterfield, 1976). These factors were taken into consideration in developing an elementary science resource guide to accompany the Utah Elementary Science Core Curriculum. There is no research justification for inclusion of the Guide in the new methods course. The decision was pragmatic in that it was thought that the guide would be a good introduction to computer managed curriculum and would serve as an introduction to the Utah Core Curriculum.

The Utah Elementary Science Resource Guide consists of curriculum materials organized in a prescribed format and available on Apple II compatible diskettes. The resources are all keyed to Utah Elementary Science Core standards and objectives. For each standard and objective the guide supplies:

(1) a statement of the standard and objective;

(2) appropriate vocabulary keyed to World Book Encyclopedia to give content background for the teacher and/or student;

(3) one or more basic lesson plans that can be used by the teacher to achieve the stated objective;

(4) a listing of a variety of textbook sources that treat the same topic;

(5) suggestions for correlation with the rest of the curriculum, e.g. ties to math, reading, language arts;

(6) suggestions for extensions and gifted and talented

activities.

Program Goal 7.0

Traditionally, much science methods course time has been devoted to familiarizing students with curriculum materials. However, review of the literature on science methods course research reveals little or no evidence on how to best incorporate curriculum material into a methods course. (Gremli, 1985) probably identifies the most realistic variable that precludes indepth exposure to curriculum materials, that being the reality of the classroom. Given such findings, and the intuitive feeling that all existing curricula cannot be covered in any indepth way, the approach in the science methods course will be to broadly familiarize students with a variety of curriculum material, but not immerse them in any one program.

Program Goal 8.0

The merits of actual classroom practicum experiences are widely documented (Repicky, 1977; Weaver, 1979; Sunal, 1978; Harty, 1984). In the practicum, each student contracts with a cooperating teacher in one of the surrounding portal schools to teach lessons that achieve objectives in the State Core. This experience follows a defined procedure for making public school contacts, planning the lessons, teaching, and evaluation. Students with identified deficiencies in any part of the practicum may be required to repeat the practicum as often as faculty consider appropriate, or in the case of clear incompetence, may be required to fail the course at this point.

Program Goal 9.0

Topic 9.1

The concept of a convocation as a culminating experience was a product

of experience with science fairs and exposure to the "convocations" approach used in the Albuquerque public schools.

The convocations consist of a series of special sessions for elementary grade level students. Emphasis are on Type II and Type III Renzuli Triad (Renzuli, 1977) science experiences, designed primarily to reduce the gap between existing achievement and the real potential of gifted students. The special sessions may require both pre- and post-sessions in the public schools, at home, or as otherwise arranged in conjunction with a Saturday or after school experience. Participating elementary students for a given convocation are chosen from within a school on the basis of how they may benefit from the experience and how they might contribute to a convocation. The convocations are conducted by methods course students, and involve appropriate college science and education faculty, professional resources persons, and parents.

In planning the convocation, a student should consider four factors (Schwab, 1973). These are: teacher, learner, curriculum, and milieu. It is the teacher's obligation to set the agenda and decide what concepts and events contribute to a learning experience. Gowin (1981) uses the term governance rather than milieu to describe the factors that control the meaning of a learning experience.

Concept mapping will be utilized to help plan the convocation. Concept mapping focuses on concept and propositional learning as the basis upon which students construct meaning (Ausubel 1963, 1968, Ausubel, Novak and Hanesian 1978). The primary approach in Ausubel's theory is meaningful learning, as contrasted with rote learning. To learn meaningfully, students must choose to relate new knowledge to relevant concepts and propositions they already know.

Program Goal 10.0

Topic 10.1

The issue of grades and testing rests upon basic course philosophy.

In this instance, the course philosophy states:

"The basic grading philosophy is that students should only be tested on things taught in the course. Participation, including attendance and tardiness, is part of professional behavior and should be included as part of the grading system. Some components of the course should be repeatable so that all can receive full credit for those experiences. There is no target GPA for the course. The following general guidelines apply:

A=clearly demonstrates excellence in all aspects of performance.

B=Good to excellent performance in nearly all aspects of the course requirements.

C=The minimum level of performance acceptable for teaching in the elementary classroom. This does not carry the connotation of average, but rather acceptable performance in every respect.

D=Less than acceptable performance. A student operating at the level should take additional time to improve level of performance or drop out.

F=Totally unacceptable performance.

CONFORMATION TO NSTA RECOMMENDED STANDARDS

An NSTA position statement (1983) recommended standards for the preparation and certification of elementary science teachers. Much of the rationale for the stated NSTA standards is similar to the rationale for the USU methods course. The NSTA statement indicated that there is universal agreement that elementary teachers should have reasonable knowledge of science content. The first recommended standard reads as follows:

> All colleges and universities should require a minimum of 12 semester hours or 18 quarter hours of laboratory or field-oriented science including courses in each of these areas: biological science, physical science and earth science.

This standard is exceeded by the SODIA Science program in that all students are required to take 5 credits each of biology, geology, chemistry, and physics. These courses all have laboratory components. Furthermore, AAAS guidelines (AAAS, 1970) indicate that courses should be related to the science the students teach. This goal is accomplished in that all Elementary Science State Core objectives are covered in the four required content courses.

The second NSTA recommended standard relates to science teaching methods. The recommendation is achieved in all aspects by the new methods course. The recommendation reads as follows:

> Preservice elementary teachers should be required to complete a minimum of one separate course of approximately three semester hours in elementary science methods. This course should be scheduled after the science content courses have been completed and just prior to student teaching.

This recommendation is expanded to include the following related to methods course content:

> The elementary science methods course should develop instructional skills designed to assist preservice teachers to teach science processes, attitudes, and content to elementary school children, grades K-6. The course should include experiences such as hands-on activities to promote process skill

development, the selection of science content appropriate for the elementary school, the design of classroom environments that promote positive attitudes, the selection and use of a variety of instructional strategies and materials, and the development of techniques for evaluating pupil progress in science.

There is considerable emphasis in the methods course on teaching content, processes, and attitudes as components of scientific literacy. The process skills are related to "hands-on" activities and content is directly coordinated with curricula judged appropriate for elementary grade children. Specifically, the following course components relate to this recommendation:

Topics 2.1, 2.2, 2.3	Content, Process and Attitude Assessment
6.1	Scientific Literacy
6.2	Cognitive Processes
7.1, 7.2	Curriculum Materials

The third area of emphasis is related to field experiences, emphasizing the need for experiences with children.

> Preservice elementary teachers should have opportunities throughout their undergraduate years to teach science to children in schools. These field experiences in science should begin with observations and tutoring and proceed through small and large group instruction. Student teaching must include experiences in planning and teaching science."

The initial exposure to students in Level II of the SODIA program may or may not include science experience. The classroom exposure at that level is unstructured to the extent that students may not be assigned at a time that science is taught or with a teacher who is teaching science. The exposure during the practicum component of the methods course provides every student the opportunity to teach science. This is followed by Level III, a full quarter methods related practicum, during which every student is required to teach science. Final classroom exposure is a full quarter of student teaching that normally includes science teaching.

Recommendation four relates to faculty preparation. Faculty for both the content and methods courses meet NSTA standards. Content course

faculty have a high interest in teacher preparation. Methods course faculty are well versed in content and in teaching methodologies.

Recommendation five emphasizes the need for an atmosphere in which students can explore, investigate, and discover. Preservice teachers should have an appreciation for the nature of scientific inquiry, the assumption being that teachers prepared in environments that invite and support curiosity, investigation, and inquiry are more likely to provide similar situations for their students.

> Preservice elementary teachers should be instructed in science laboratories and educational facilities that include equipment, instructional materials, and library holdings that promote science learning and exemplify outstanding school science programs.

The combination of science course laboratories, the science society and technology methods course component, and the Edith Bowen Lab School facilities collectively satisfy the requirements of this recommendation. The one area of deficiency lies in that there is no annual budget for supplies and equipment.

The final recommendation defines conditions relative to professional development. These skills range from positive attitude toward science to an appreciation for the position of science in the total elementary curriculum.

> The professional orientation of preservice elementary teachers should include experiences that (a) instill positive attitudes toward science and science teaching, (b) foster an appreciation for the value of science in the total curriculum and in the lives of the children, and (c) develop a commitment to continue their education as teachers of science through reading, participating in professional organizations, and furthering education, including inservice experiences.

Item "c" above has not been evaluated, but items "a" and "b" are integral parts of the philosophy and objectives of the methods course.

SUMMARY

This paper has reported the philosophical research and foundation for SODIA-Science, a science methods course for preservice elementary teachers. The general philosophy emphasized the importance of "hands on" individualized curriculum.

Student success can be best achieved in a helping relationship situation in which the instructor and student interact in a problem solving-helping relationship.

Course development was carried out using a discrepancy evaluation model, with a program network, a course objective framework, and component IPO's. Development of these aspects of the program was carried out with the assistance of an advisory committee consisting of science education faculty, science faculty and public school representatives.

Additional justification was presented for each program goal. Where possible, some research justification was presented for each major course component. The final section evaluated the new course program against NSTA recommended standards.

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